Systems Engineering Processes Applied To Ground Vehicle Integration at US Army Tank Automotive Research, Development, and Engineering Center (TARDEC)

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GVSETS

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Mission:

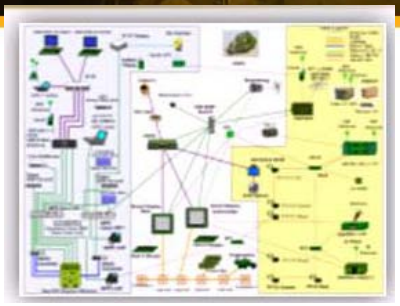
CGVDI provides the Department of Defense a single project management office that coordinates activities across RDECOM and DoD to conduct the complete spectrum of activities required for design, development, fabrication, integration and testing of ground systems (manned or unmanned) from engineering changes to technology/capability insertion to full system prototypes in order to meet the needs of the warfighter.

Center for Ground Vehicle Development & Integration

SYSTEMS ENGINEERING AND INTEGRATION

Description

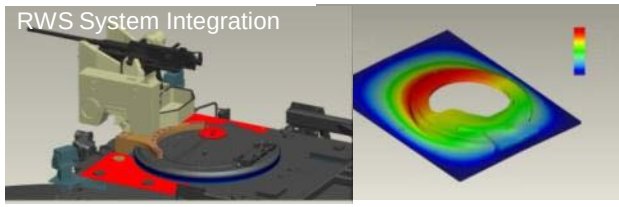
- Leverages RDECOM and DoD capabilities in a repeatable process to apply rigorous systems engineering to ground systems integration
- Provides customer partners a single entry point for cost, schedule, performance and risk management of system integration projects



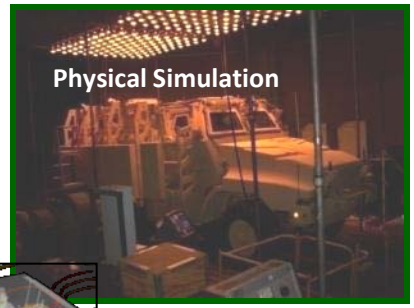
System Architecture

Notable Recent Accomplishments

- MRAP Capability Insertion for Caiman, MaxxPro, RG-31 and RG-33 Systems
- Command and Control on the Move (Stryker and MRAP Integrations)
- Robotic Deployment System



Employs TARDEC organic Concepts, Analysis, System Simulation and Integration (CASSI), System Engineering (SE), and significant contributions from other RDECs and Organizations



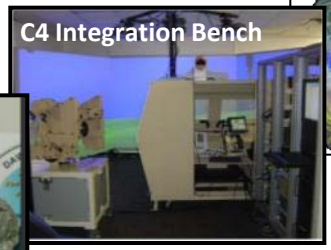
MRAP Capability Insertion

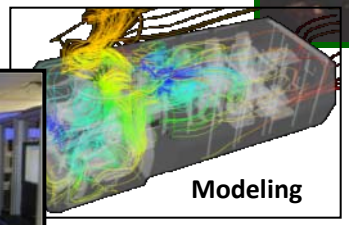
- **Vanguard**
  - —CROWS II Remote Weapon Station
  - —Boomerang
  - —Double Shot
- **LRAS3**
- **Check 6 Camera**
- **OGPK Overhead Protection**
- **Overhead Wire Mitigation**
- **IBIS TEK Lights**
- **RPG Protection**
- ***Power Upgrade (derived requirement)***
- ***C4I Architecture (derived requirement)***
- **Thrown Object Protection System**

CGVDI Projects (active):

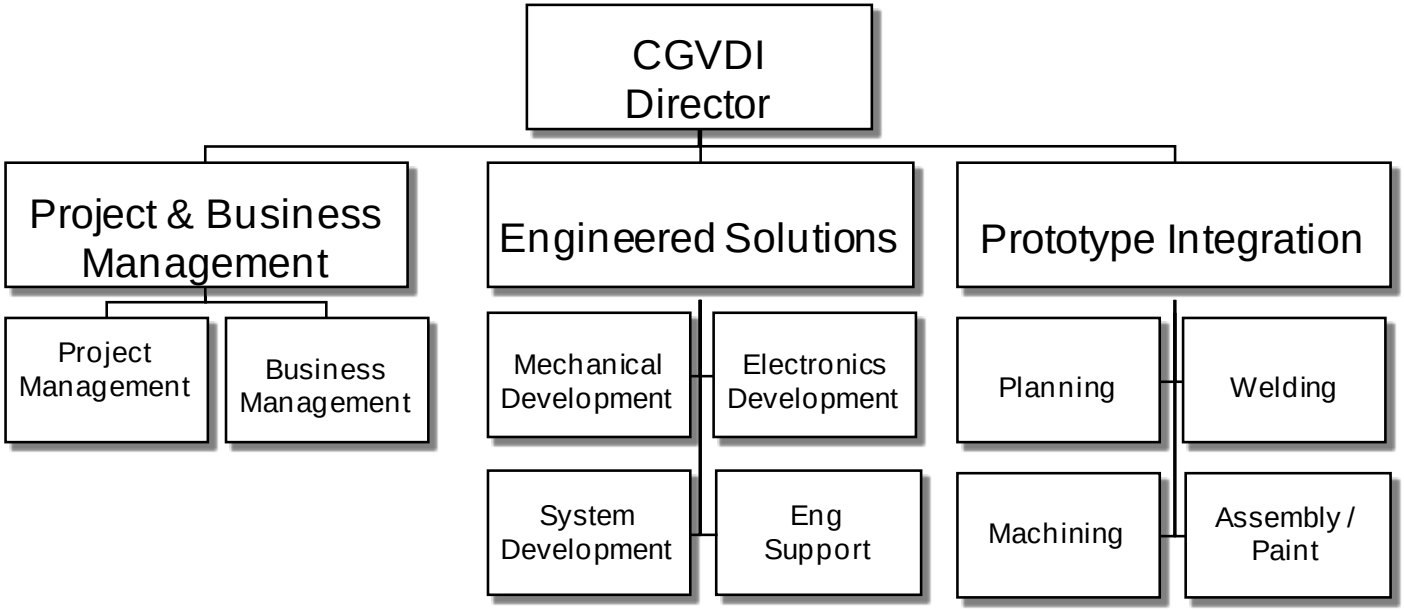
- *MRAP Capability Insertion*
- *C2OTM* – MRAP*
- *C2OTM* – Stryker*
- *LAV-R Upgrade*
- *RS-JPO*
- *PM-AMS*

*Command & Control On The Move





Organizational Structure

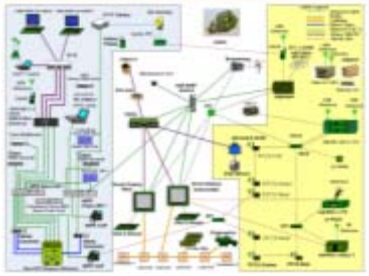


CGVDI combines TARDEC's Ground Vehicle Integration Center and Prototype Integration Facility to create an improved, integrated capability.

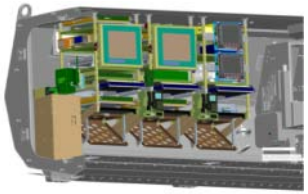
CGVDI Projects

- Initial MRAP CI Scope: Capability Insertion System Integration for Caiman, MaxxPro, RG-31, and RG-33
  - System Development & Integration
  - Analyses
  - Installation Manuals
  - VAL/VER Kit
  - Spare Parts
  - Initial Production
  - Level III TDP
- New MRAP Scope
  - MaxxPro Dash CI
  - MATV CP 11-12
  - Caiman Ambulance
- Other Significant Efforts
  - Command & Control On The Move (C2OTM)
    - Caiman
    - Stryker
    - MATV
  - LAV-R Upgrade
  - Robotic Deployment System
  - MRAP Egress Assistance Trainer
  - Universal Combat Lock Tool

Sample Deliverables



Updated Architecture Requirement



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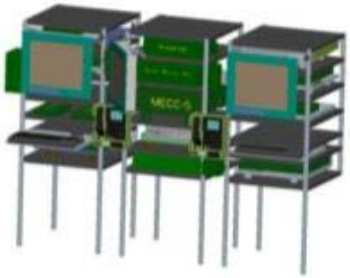


Systems Integration Lab

Fully Integrated Test Asset

Fully Integrated Caiman First Unit Equipped Asset

8 Vehicle A Kits for Installation

2 Spare Kits

1 Validation Kit

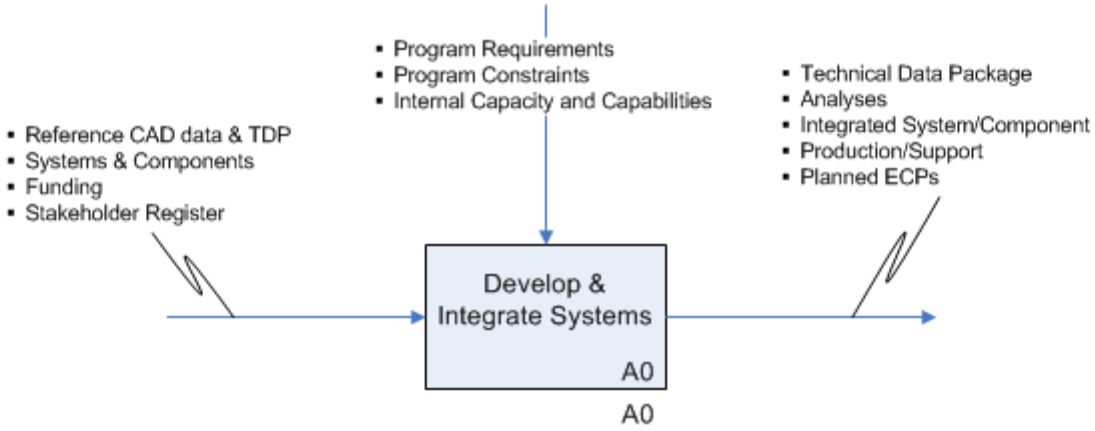
- Antenna Analysis
- Power Analysis
- Thermal Analysis
- Blast Analysis
- HFE Analysis
- Safety Analysis

Level II Drawings

FSR Level Install-Manuals

Level III Drawing Package

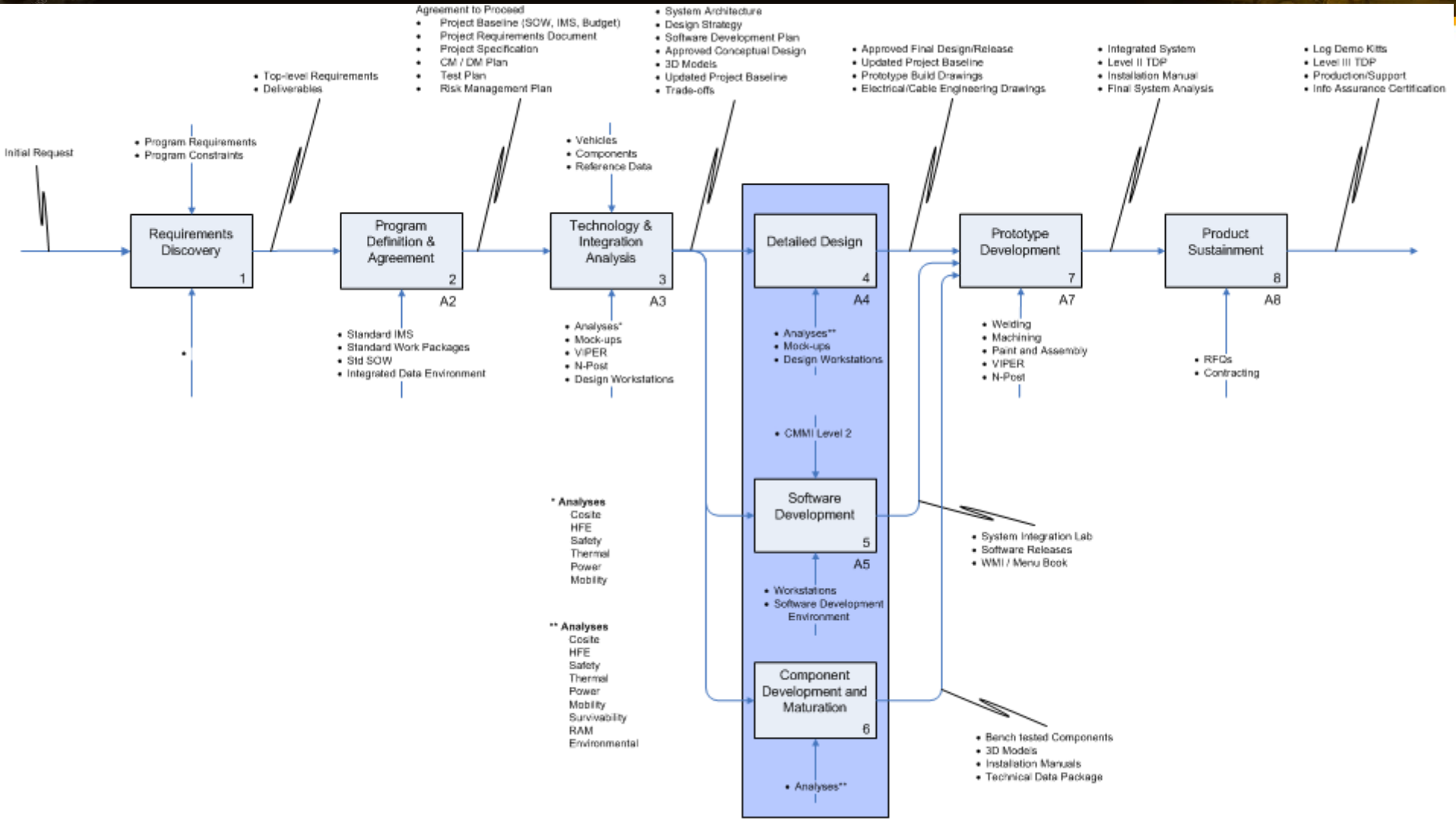
System Development & Integration Process



Purpose: To ensure rigorous system engineering principles are applied in a repeatable fashion to all TARDEC System Development & Integration projects

System Development & Integration Process

SYSTEMS ENGINEERING AND INTEGRATION



System Integration Process

- JUONs
- CPD
- PM Directed

- MOA
- IMS
- Budget

- Models
- Trade-offs
- Integration Concepts

- Approved Concept

- TRL 6 Components

- Prototype Solution
- Level II Drawings
- Integration Validation

- Level III Drawings
- Test Support

S → 1.0 Receive & Analyze Capability Request → 2.0 Program Definition & Agreement → 3.0 Technology & Integration Analysis → 4.0 Solution Set Meets Vehicle SWaP constraints? (YES → 5.0 Component Development/ Maturation → 6.0 Prototype Development → 7.0 System Meets Customer Expectations? (YES → 8.0 Fielding Support → E; NO → Customer Decision)

4.0 NO → 3.0

7.0 NO → Customer Decision

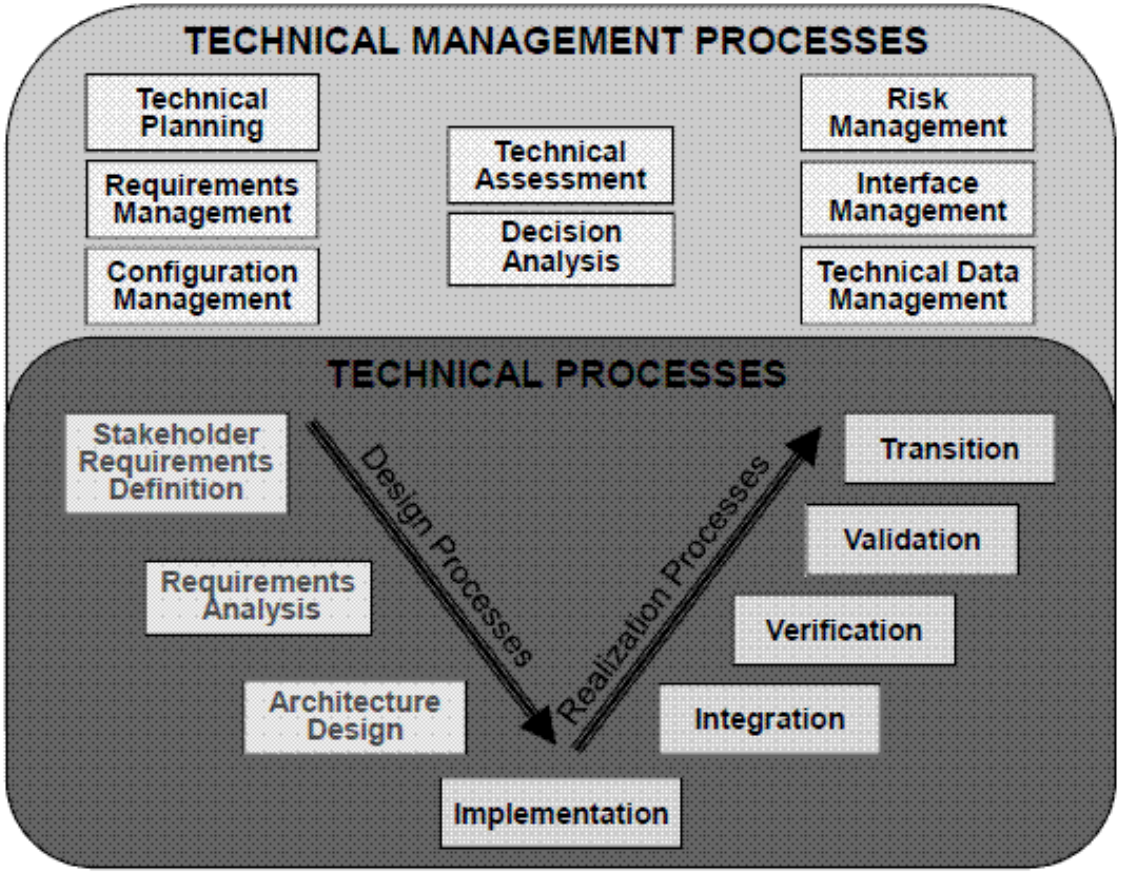
Requirements Review

Integration Review

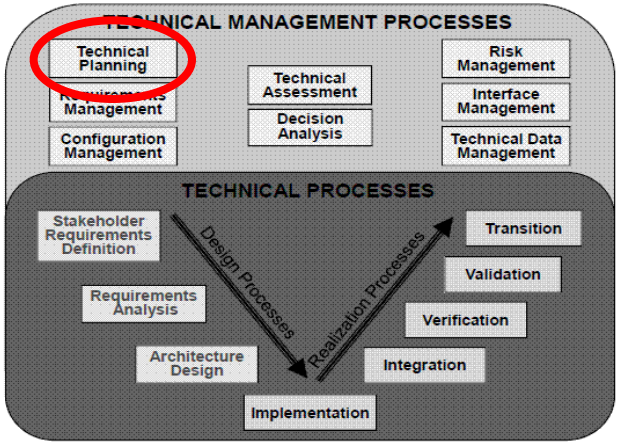
In-Progress Reviews

Initial & Final Design Reviews

Ship to Test Review

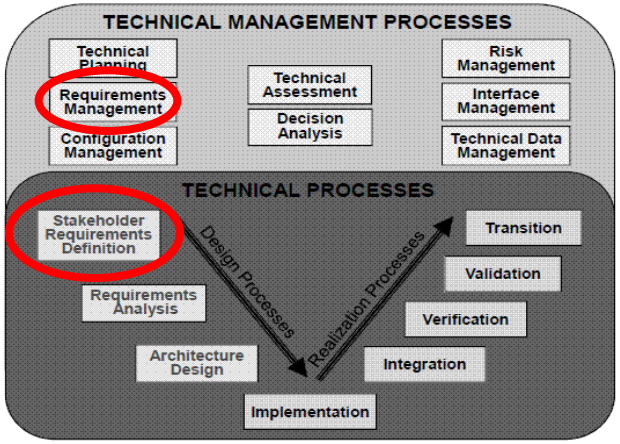


DEPARTMENT OF DEFENSE SYSTEMS ENGINEERING PROCESS MODEL 2009



TECHNICAL PLANNING

- Infused SE Processes Throughout the CGVDI System Development & Integration Process.
- Developed and Documented a Systems Engineering Plan (SEP) to Layout Operating Process.
  - ❑ Form the Basis for Developing Standard Operating Procedures (SOPs).
- Foundation for Planning “What” SE Processes to Implement and “How” to Implement.

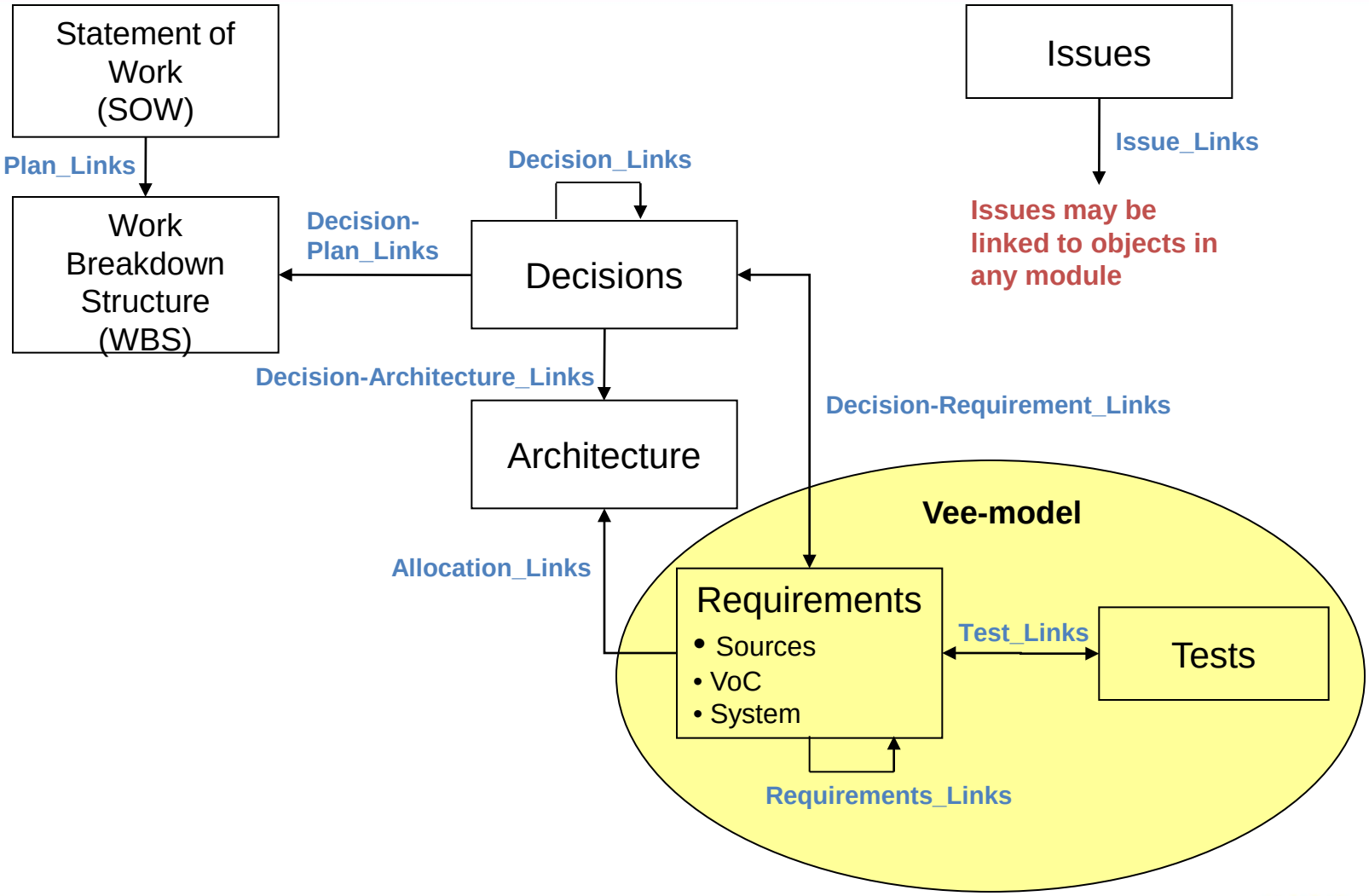


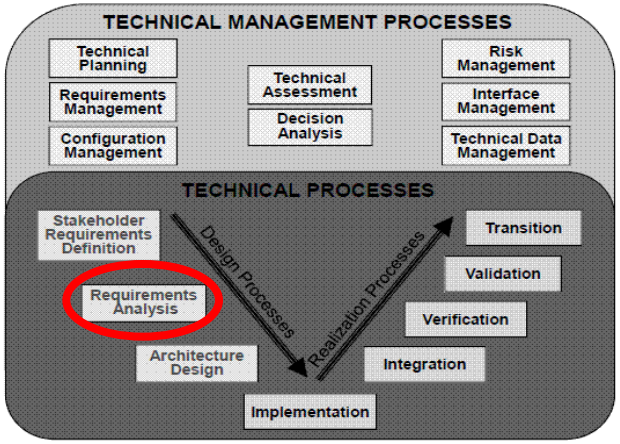
STAKEHOLDER REQUIREMENTS DEFINITION

- Requirements Management Process Implemented to:
  - ✓ Capture Project Requirements
  - ✓ Organize Project Requirements
  - ✓ Analyze Project Requirements
  - ✓ Trace Project Requirements

- Requirements Gathering From Sources Such As:
  - ➢ Project Statement of Work
  - ➢ Customer Input/Documents
  - ➢ System Requirements
  - ➢ Derived Requirements
  - ➢ Lessons Learned

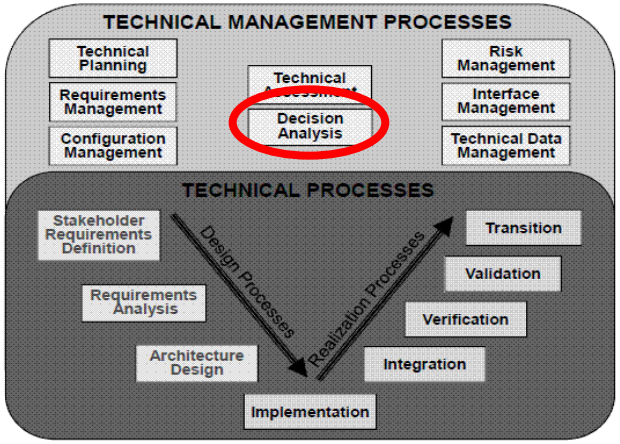
REQUIREMENTS INFORMATION MODEL





REQUIREMENTS ANALYSIS

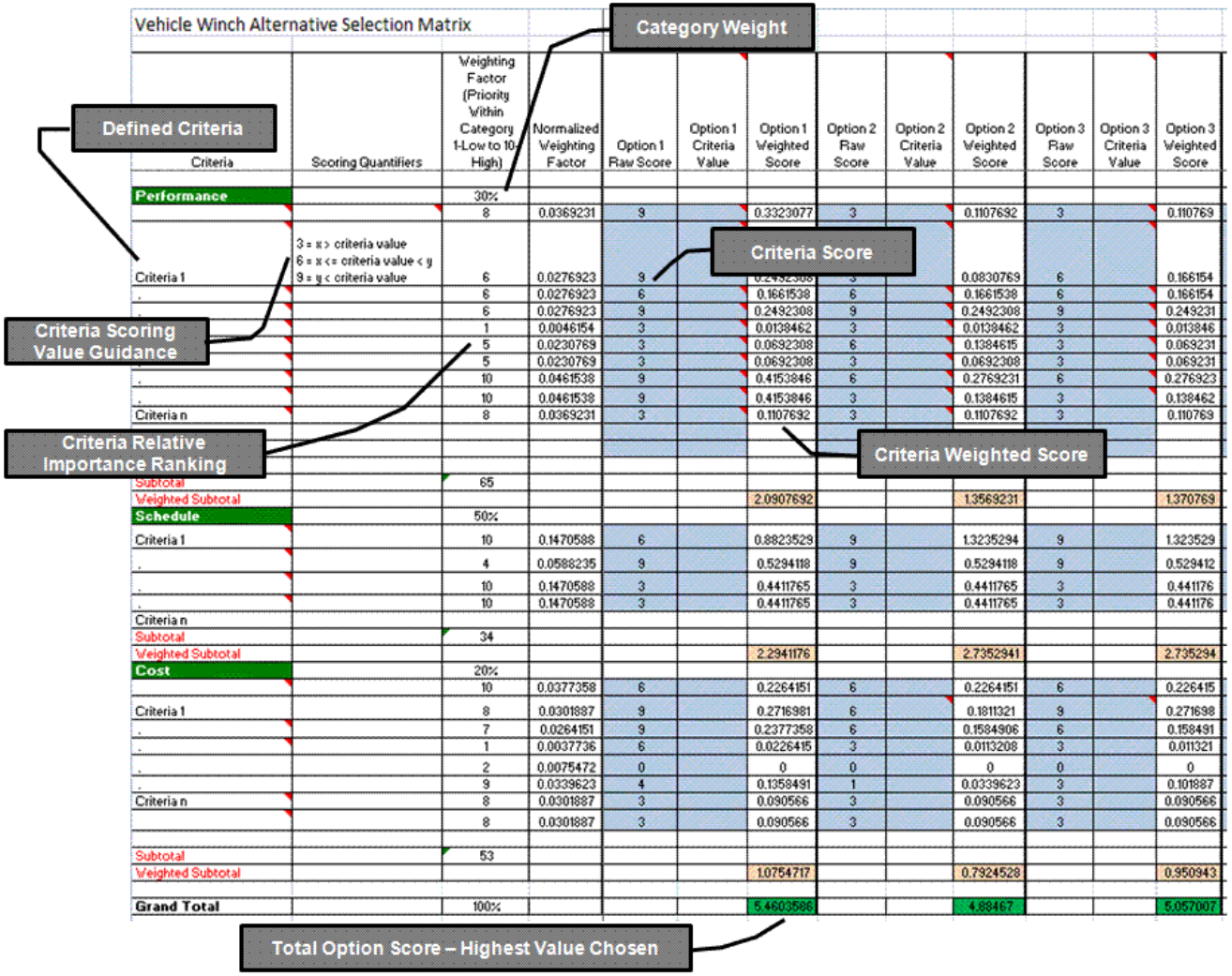
- Requirements Decomposition – Ensures Requirements are:
  - ✓ Singular
  - ✓ Concise
  - ✓ Unambiguous
  - ✓ Verifiable
- Requirements Traceability– Provides Confidence in Project Completion (Gap Analysis) :
  - ✓ All Requirements Are Allocated to Architecture/Solution
  - ✓ All Requirements Are Linked to Verification Method



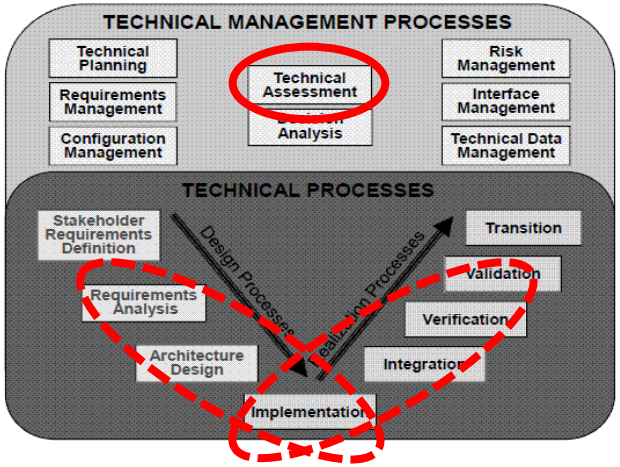
DECISION ANALYSIS

- Alternative Solutions Selection
  - Define Criteria
  - Assign Weighting Factors
  - Assign Relative Category Importance (Cost, Schedule, Performance)

DECISION ANALYSIS TOOL

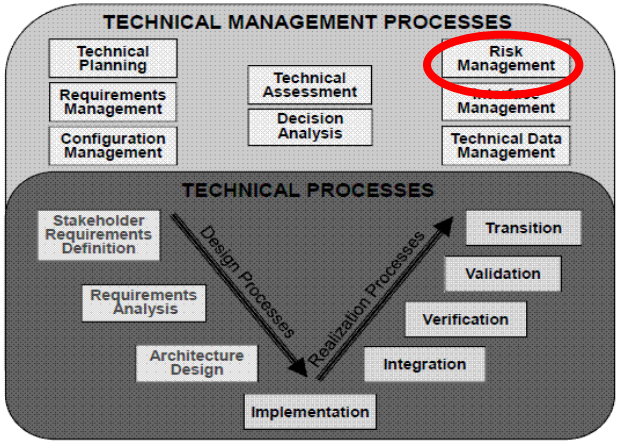


Criteria	Scoring Quantifiers	Weighting Factor (Priority Within Category 1-Low to 10-High)	Normalized Weighting Factor	Option 1 Raw Score	Option 1 Criteria Value	Option 1 Weighted Score	Option 2 Raw Score	Option 2 Criteria Value	Option 2 Weighted Score	Option 3 Raw Score	Option 3 Criteria Value	Option 3 Weighted Score
Performance		30%										
		8	0.0369231	9		0.3323077	3		0.1107692	3		0.110769
Criteria 1	3 = x > criteria value 6 = x <= criteria value < y 9 = y < criteria value	6	0.0276923	9		0.2492308	3		0.0830769	6		0.166154
.		6	0.0276923	6		0.1661538	6		0.1661538	6		0.166154
.		6	0.0276923	9		0.2492308	9		0.2492308	9		0.249231
.		1	0.0046154	3		0.0138462	3		0.0138462	3		0.013846
.		5	0.0230769	3		0.0692308	6		0.1384615	3		0.069231
.		5	0.0230769	3		0.0692308	3		0.0692308	3		0.069231
.		10	0.0461538	9		0.4153846	6		0.2769231	6		0.276923
.		10	0.0461538	9		0.4153846	3		0.1384615	3		0.138462
Criteria n		8	0.0369231	3		0.1107692	3		0.1107692	3		0.110769
Subtotal		65										
Weighted Subtotal						2.0907692			1.3569231			1.370769
Schedule		50%										
Criteria 1		10	0.1470588	6		0.8823529	9		1.3235294	9		1.323529
.		4	0.0588235	9		0.5294118	9		0.5294118	9		0.529412
.		10	0.1470588	3		0.4411765	3		0.4411765	3		0.441176
.		10	0.1470588	3		0.4411765	3		0.4411765	3		0.441176
Criteria n												
Subtotal		34										
Weighted Subtotal						2.2941176			2.7352941			2.735294
Cost		20%										
		10	0.0377358	6		0.2264151	6		0.2264151	6		0.226415
Criteria 1		8	0.0301887	9		0.2716981	6		0.1811321	9		0.271698
.		7	0.0264151	9		0.2377358	6		0.1584906	6		0.158491
.		1	0.0037736	6		0.0226415	3		0.0113208	3		0.011321
.		2	0.0075472	0		0	0		0	0		0
.		9	0.0339623	4		0.1358491	1		0.0339623	3		0.101887
Criteria n		8	0.0301887	3		0.090566	3		0.090566	3		0.090566
		8	0.0301887	3		0.090566	3		0.090566	3		0.090566
Subtotal		53										
Weighted Subtotal						1.0754717			0.7924528			0.950943
Grand Total		100%				5.4603586			4.88467			5.057007



TECHNICAL ASSESSMENT

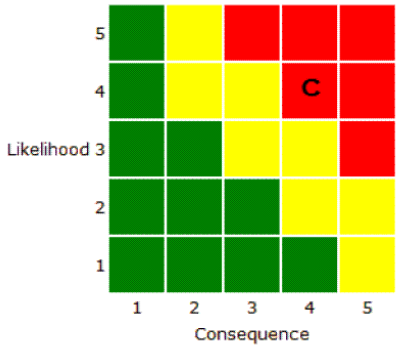
- Technical Reviews Based On Formal Reviews Defined in Defense Acquisition Guidebook.
  - ➢Less Formal Implementation (Formal Reviews Reserved for Major Defense Acquisition Programs)
- Reviews Include:
  - ✓ Project Requirements Review
  - ✓ Project Functional Review
  - ✓ Integration Review
  - ✓ Initial Design Review
  - ✓ Final Design Review
  - ✓ Risk Management Reviews
  - ✓ Stakeholder Integrated System Review
  - ✓ Functional Verification Audit
- Entry/Exit Criteria Used To Determine Outcome (Pass, Fail, Pass with Follow-Up).

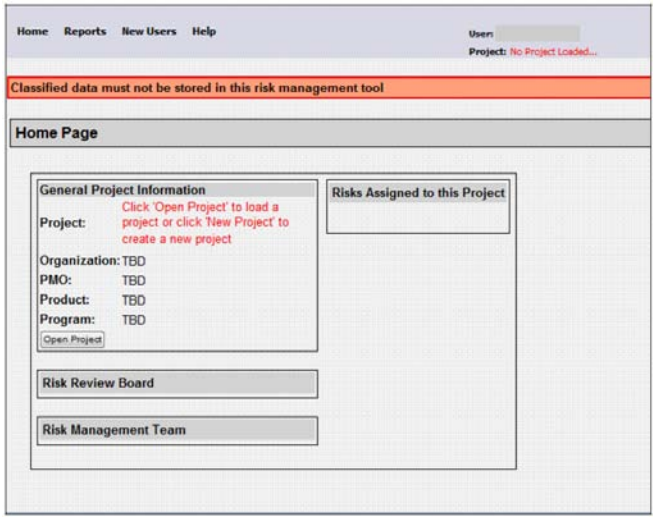


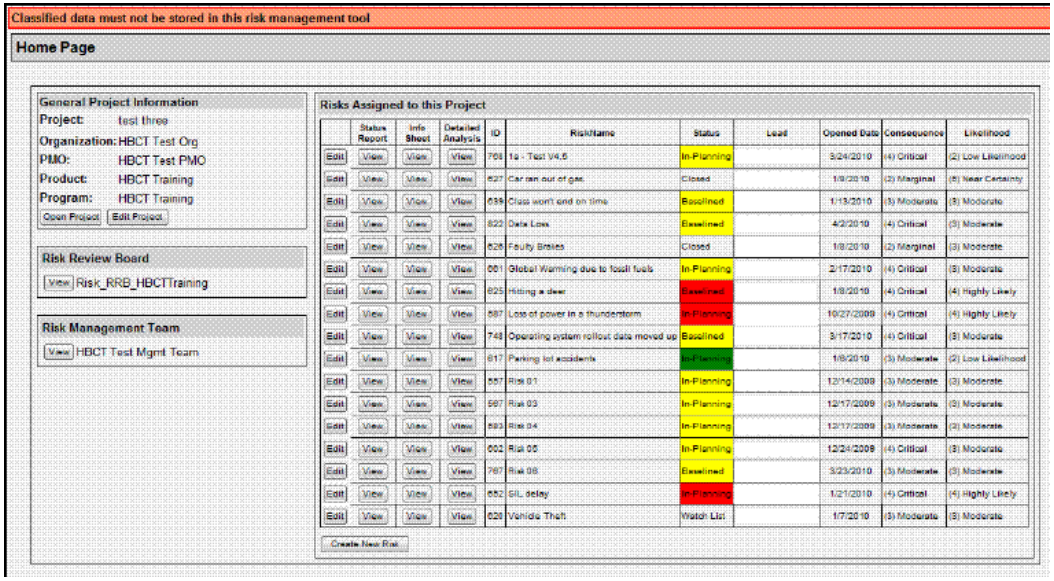
RISK MANAGEMENT

- Project Risks Continuously Evaluated In Areas Such As:
  - Performance
  - Cost
  - Schedule
- Risks Managed Using Risk Management Tool called “Risk Recon” Developed by Program Executive Office (PEO) Ground Combat Systems (GCS).

RISK MANAGEMENT TOOL







SUMMARY

- The Systems Engineering Revitalization In the Department Of Defense is Gaining Momentum At TARDEC Through the Systems Engineering Group's Effort.

- The Center For Ground Vehicle Development And Integration's System Development And Integration Process Has Become An Excellent Implementation Of The Systems Engineering Process Model.